Space Weather Technical Forecast

Issued on Sunday 22 December 2024 at 00:27 Local

This technical forecast provides a four-day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

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Space Weather Forecast Headline: R1/R2 Likely. Uncertainty in geomagnetic forecast.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Solar activity has been Moderate due to a single impulsive M1.9 flare at 21/0038 UTC from AR3932 in the southeast.

There are currently ten sunspot regions on the visible disc. The former elongated AR3927 is now split into two regions, with the larger trailing eastern bipolar portion comprising AR3933. Both regions are located in the southeast quadrant. Other recent changes include newly numbered bipolar AR3934 toward the northeast limb, and some further minor growth in the still relatively small bipolar region AR3930 in the southwest quadrant. The southeastern quadrant contains a cluster of the largest and most complex regions on the disc; the already mentioned AR3927 and AR3933, along with AR3928 and AR3932 located to the south. Both are moderately wide bipolar regions and are currently classified Eai/Beta. Remaining regions are relatively small, stable and magnetically simple.

Confidence in the complex number of Coronal Mass Ejections (CMEs) is currently low.

A filament lift-off from the northeast from late in the UTC day on 20 Dec was modelled and gives a potential peripheral glance around 24/0000 UTC.

A number of other CMEs (coronal mass ejections) have been observed in available imagery during the period. These include a filament eruption 21/0430UTC from the southwest quadrant near S30W040, two significant eruptions from the vicinity of the northeastern limb around 21/1000 UTC and 21/1930-2000 UTC. A large filament lifted off the northwest disc around 21/1000UTC, a filament lift off from near the west limb around 21/2000 UTC, and a narrow eruption from the southeast quadrant near AR3932 around 21/2100 UTC. Analysis of the above events is ongoing to determine if any present a possible Earth directed component.

Solar Wind / Geomagnetic Activity: Solar winds, observed at L1 by DSCOVR and ACE have shown Elevated conditions with uncertain cause - perhaps coronal hole influence. The solar wind speed showed a gradual, erratic increase from Slightly Elevated to Elevated levels from near 480 to 550km/s. The solar wind density differed according to the measuring satellite, with ACE and Background single figures ppcc perhaps preferred. The IMF was Slightly Elevated at times around 9nT, with an erratic north-south component ranging between +/-8nT.

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Geomagnetic activity was Quiet to Active Kp (2 to 4), peaking in the 21/0300-0600UTC interval, as measured by BGS.

Energetic Particles / Solar Radiation: High energy proton flux (greater than 10MeV) observed by GOES18 gradually increased in the period before levelling off over the past few hours but remained sub-S1 (10pfu), reaching 5.2pfu at 21/1820UTC.

High energy electron flux (greater than 2MeV) observed by GOES16 peaked at Moderate levels, with 757pfu observed at 21/1955UTC. The associated 24-hour fluence was below the Active (1e8 integrated flux) threshold. The 22/0001UTC observation was 2.07e7 integrated pfu, with a slight rising trend.

Four-Day Space Weather Forecast Summary

Solar Activity: Isolated M-class flares are Likely, mainly from AR3928 or AR3932, perhaps bolstered slightly after the current UTC weekend by returning regions. A Slight Chance of isolated X-class flares is maintained throughout.

Solar Wind / Geomagnetic Activity: A filament lift-off from the northeast from late in the UTC day on 20 Dec was modelled and gives a potential peripheral glance around 24/0000 UTC. There are also a number of other CMEs (coronal mass ejections) observed during the period which are yet to be fully assessed, but these appear to be directed off the Sun-Earth line in the main.

Overall, and given now-Elevated solar wind speeds, there is a Slight Chance of Minor Storm G1 conditions through the period, tentatively peaking around days 2 and 3 (23 and 24 Dec) due to CH01/-and possible glancing influence from 20 Dec CME.

Energetic Particles / Solar Radiation: There is a Chance of S1-level or greater enhancements in the current UTC weekend due to current slightly enhanced near-Earth proton counts. This risk should relax back in the absence of any significant flares, with most of the risk from the front-side then tied to the westward advance of the cluster of southeastern sunspot regions.

The high energy electron forecast carries lower-than-average confidence due to inherited uncertainties from the geomagnetic forecast, especially surrounding any possible onset of CH01, and potential glancing CME influence. Overall, the chances of disturbances in the period are higher than average, with perhaps a gradually rising Slight Chance perhaps the best representation.

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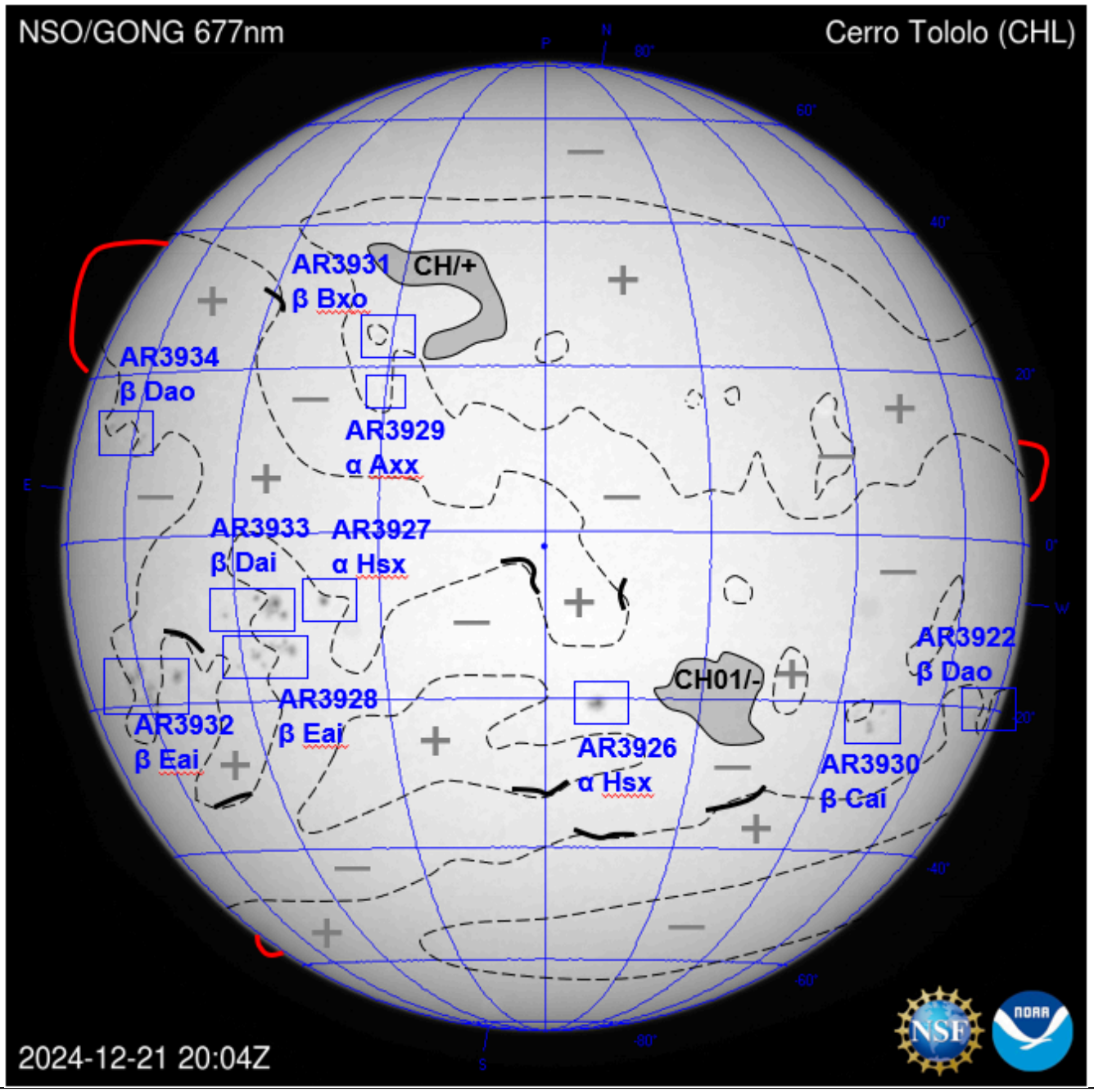
Figure 1: Solar synoptic map valid 21/2000UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms

A filament lift-off from the northeast from late in the UTC day on 20 Dec was modelled and gives a potential peripheral glance around 24/0000 UTC. There are also a number of other CMEs (coronal mass ejections) observed during the period which are yet to be fully assessed, but these appear to be directed off the Sun-Earth line in the main.

Current solar winds are Elevated via an uncertain mechanism, potentially early connection to CH01/- given the phi angle. The coronal hole itself has shown changes in shape over the past three or four days, making onset forecasting more complicated. Flux looping to its immediate west in GOES SUVI 195 imagery may be masking any leading portion of this hole, although the main feature still seems rather far east for current observations, and there may be an alternative cause. This is the main forecast feature due in the period, and the fact that it may already be in course lowers confidence for the forecast as a whole. CH01/- itself is a non-persistent feature, further exacerbating the issue.

Overall, and given now-Elevated solar wind speeds, there is a Slight Chance of Minor Storm G1 conditions through the period, tentatively peaking around days 2 and 3 (23 and 24 Dec) due to CH01/-and possibly glancing influence from 20 Dec CME. A mitigating factor against larger effects from any coronal hole is being near the semi-annual minimum coronal hole geoeffectivity near the solstice.

Geomagnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	No	5	10	20	5
Strong	G3	No	1	1	5	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

Geomagnetic Activity - Earthbound Coronal Mass Ejections

Date/time 21.5R⊙ (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed (km/s)	Estimated Arrival Time (UTC)	Comments
21/0535 UTC	Partial	Filament	NE quadrant	532	24/0000 UTC	Possible glance but low confidence.

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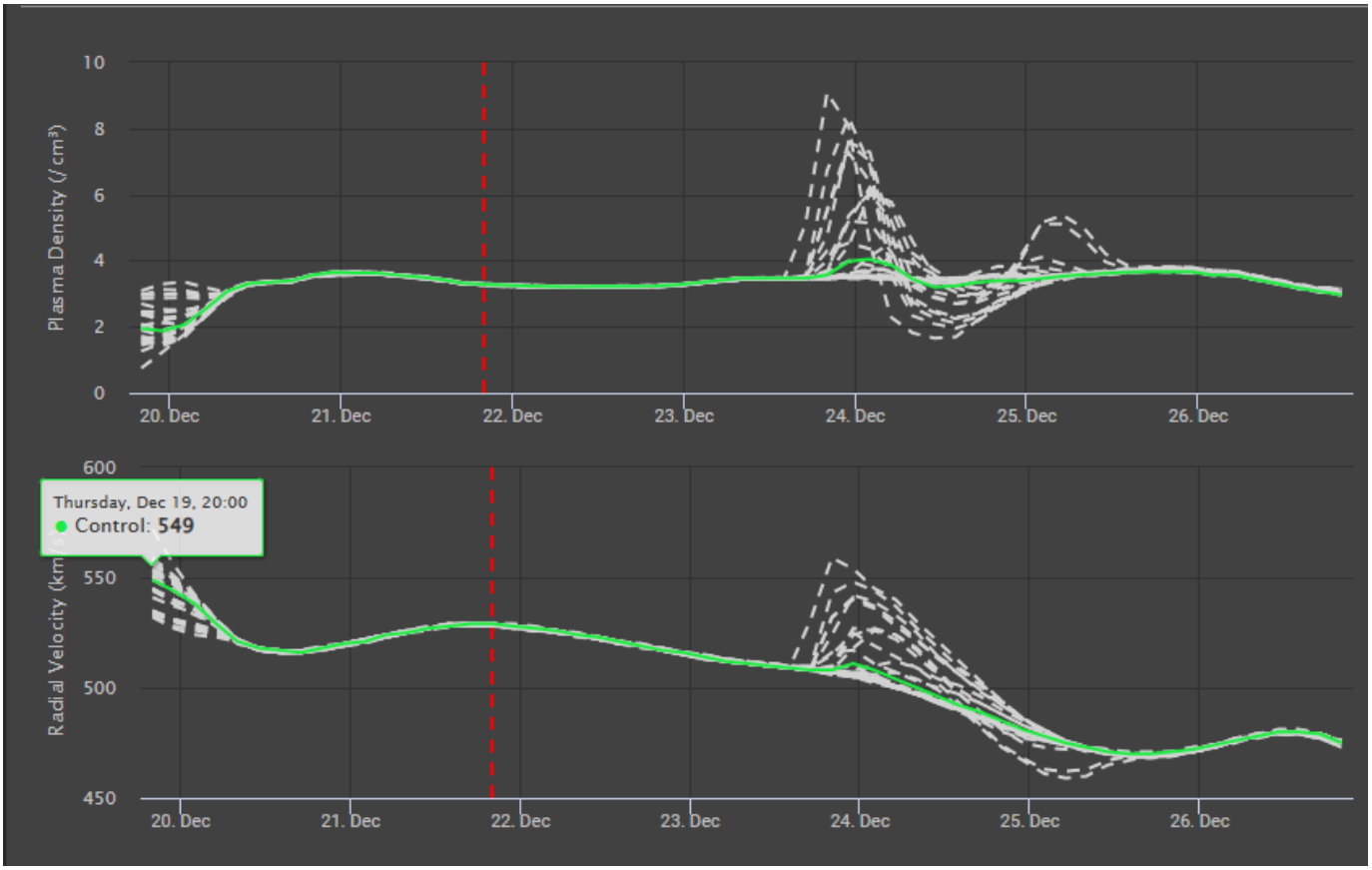
Figure 2: MOSWOC Enlil Ensemble output, showing possible glancing CME influence around 24/0000 UTC from 20 Dec CME.



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Radio Blackouts - X-Ray Flares

Solar activity has been Moderate due to a single impulsive M1.9 flare at 21/0038 UTC from AR3932 in the southeast. Further M-class flares are considered likely, with a slight chance of X-class flares. The most likely source being from the grouping of regions in the southeast quadrant.

There are currently ten sunspot regions on the visible disc. The former elongated AR3927 is now split into two regions, with the larger trailing eastern bipolar portion comprising AR3933. Both regions are located in the southeast quadrant. Other recent changes include newly numbered bipolar AR3934 toward the northeast limb, and some further minor growth in the still relatively small bipolar region AR3930 in the southwest quadrant. The southeastern quadrant contains a cluster of the largest and most complex regions on the disc; the already mentioned AR3927 and AR3933, along with AR3928 and AR3932 located to the south. Both are moderately wide bipolar regions and are currently classified Eai/Beta. Remaining regions are relatively small, stable and magnetically simple.

There is the potential for some further eastern limb returning regions over the current UTC weekend, perhaps foremost amongst these being Ex-AR3910, with Ex-AR3912 then also due Monday 23 December.

X-Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 (M Class)	Yes	65	70	75	75
Very Active	R3-R5 (X Class)	No	10	10	10	10

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Solar Radiation Storms (High Energy Protons)

The source of the currently observed enhancement in the near-Earth environment is uncertain, but given the damped rise and soft spectrum, an eastern solar hemisphere or far-sided source seems most likely, perhaps from 19 December with possible further additions since. The chances of S1-scale or greater events are currently slightly raised as a result of the increased counts, however barring further additions, a relaxing back towards the raw disc value of 15% is forecast for a time. An increasing trend is then anticipated as the main southeastern sunspot regions advance westwards.

Radiation Storms Probability (Exceedance)	Level ($cm^{-2}sr^{-1}s^{-1}$)	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	No	20	15	20	20
Very Active	**≥ S3 ***	No	1	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and/or 50 MeV ≥ 10pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

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High Energy Electrons (≥ 2MeV)

The current high energy electron flux is oscillating between background and moderate levels. This trend may abruptly accelerate at GEO given recently observed Elevated solar winds and Unsettled geomagnetic activity, with the period as a whole carrying low confidence as a result of an uncertain CME picture and non-recurrent - and in fact possibly already underway - coronal hole.

MOSWOC REFM gives a reasonable guide, although does not represent either any impinging CME activity nor non-persistent coronal holes, and as such the forecast carries low confidence as already mentioned.

All considered, there is a gradually rising Slight Chance of 24-hour fluence reaching Active.

GEO Electron Environment	Level ($cm^{-2}sr^{-1}$ day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Active	≥ 2 MeV ≥ 1×10^{8}	No	5	5	10	10
Very Active	≥ 2 MeV ≥ 1×10^{9}	No	1	1	1	1

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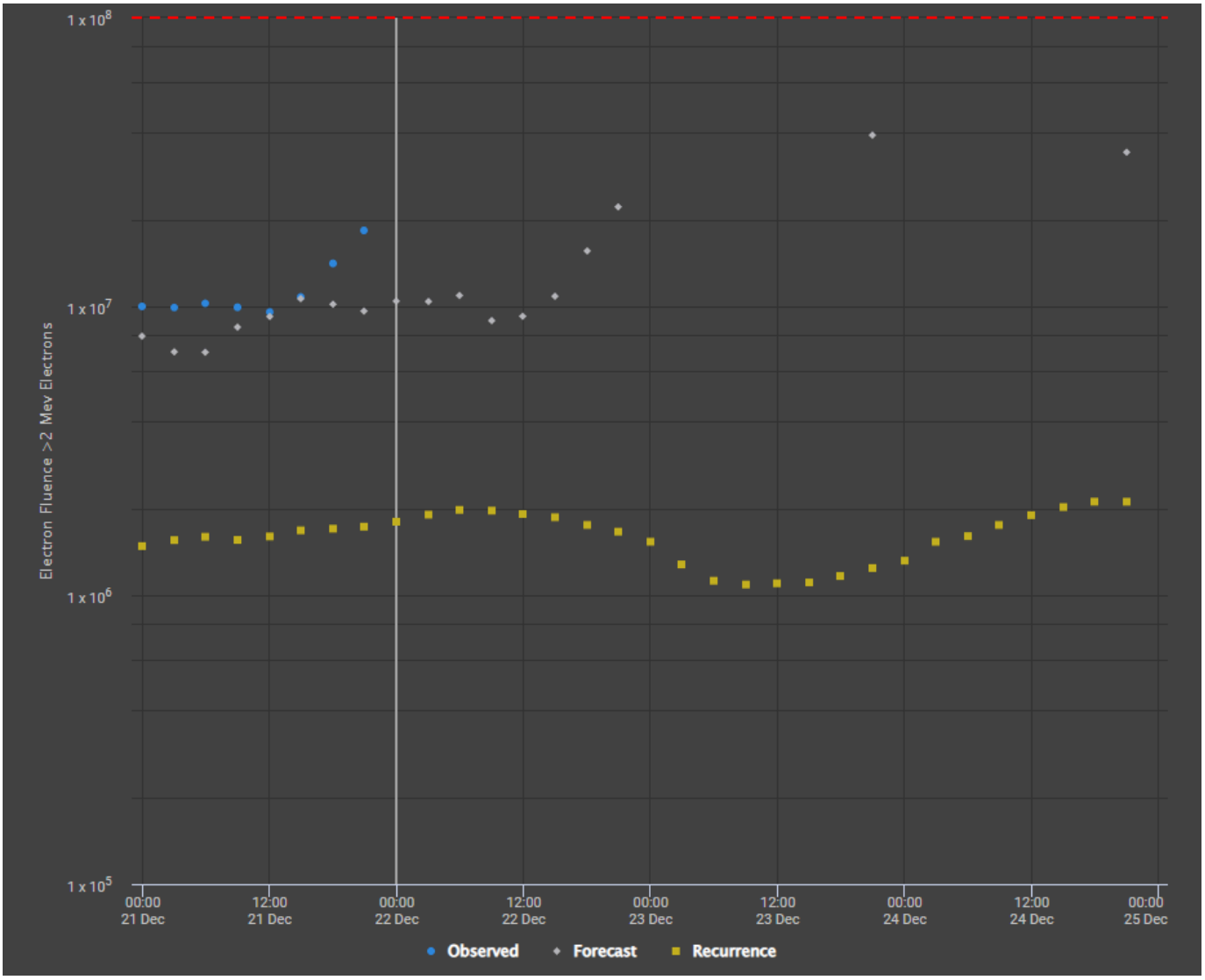
Figure 3: MOSWOC REFM latest



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